International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 7 Issue 3, May-June 2023 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

An Extended Global Literature Review of Data Envelopment Analysis

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ABSTRACT

The present bibliographic literature review is to study DEA for two years 2020 and 2021 (upto August 2021). On examining the articles on DEA models globally, 1166 articles have been gathered for review. They are classified according to author, purpose of research, country, methods and other outcomes and results. This study common applications in agriculture, Banking, ecology, education, environment, energy, power, industry, transportation, service sector, product planning, maintenance, hotel industry, supplier selection cum distribution and environmental factors. Among all the applications, the second highest are in banking sector. The big contributors are China, India, Iran Most of the authors, precisely as many as, 988 have contributed single article only while the maximum contribution of single author is nine by Chia-Nan Wang from China. DEA continues to be preferred even after its postulation forty years ago.

KEYWORDS: *Data Envelopment analysis, systematic review, banking, articles, global level, DEA*

How to cite this paper: J Sathyamurti | Dr. David Sam Jayakumar "An Extended Global Literature Review of Data Envelopment Analysis" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-7 | Issue-3, June 2023, pp.1279-1293, URL: www.ijtsrd.com/papers/ijtsrd52628.pdf

IJTSRD52628

1. INTRODUCTION

Data envelopment analysis (DEA) has been found to be widely applied in various fields such as agriculture, banking, ecology, education, energy, environment, finance, Government entities, health care, insurance, manufacturing, mining, power, real estate, supplier selection, transportation, sport, tourism, and water (Liu, Lu, Lu, & Lin, 2013). DEA has become one of the prominent non-parametric performance measurement approaches to find out the efficiency scores of a set of homogeneous decision-making units (DMUs) when inputs and outputs are multiple (Emrouznejad & Yang, 2018). After the postulation of DEA by Charnes, Cooper, and Rhodes, (1978) as based on Farrell's (1957) study, more than 10,000 articles have been published all over the world. WWW.DEAZONE.COM has published bibliography containing 10,670 articles and the article of Reza Rostamzadeh (2021) reviewed the articles on DEA upto February 2020. Thereafter global coverage of DEA articles is a gap. Here an attempt is made to review the DEA researches upto August 2021. The study is a bibliographical approach of review by its focus on 1166 articles from 89 countries.

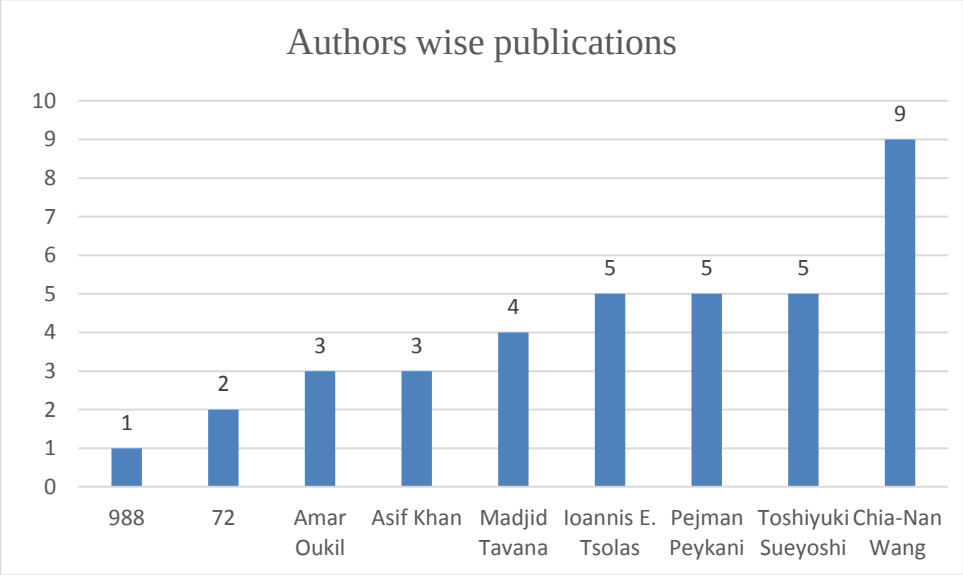
2. Global level review of articles on DEA

As many as 1166 articles are ,in total, gathered by rejecting duplicates and unrelated on tracing in 1) Research net-working sites like Academia, Dimensions, Google Scholar, Publon, worldcat, DOAJ 2) Research database like IEEE explore, ERI/C, JSTOR, Proquest, Science direct and 3) Journal finders like EBSCO, Emerald, Springer, Taylor & Francis and Wiley. They are analysed for its content to group them based on some parameters like the author of the article, method used, objective of the articles, page of articles, nature of publications.

For the period from january 2020 to August 2021, the maximum of nine articles are authorised by single author viz., Chia-Nan Wang from China. Next five each articles are authorised by three researchers viz., Ioannis E. Tsolas, Pejman Peykani

and Toshiyuki Sueyoshi. Four articles are by Madjid Tavana from USA; three each articles are by Amar Oukil and Asif Khan; two articles each by 73 articles; 988 articles are authorised each one by 988 researchers. Thus, in total, 1166 articles are the research work of 1066 authors.

Figure 1. Publications based on number of articles by authors



A total of 89 countries published 1166 articles. The maximum of 241 articles are from China; 162 articles from India; 130 articles from Iran. The list given below furnishes the research work of each nation. As many as 30 countries produced only single article related to DEA.

Figure 2. 30 nations contributing each one article on DEA

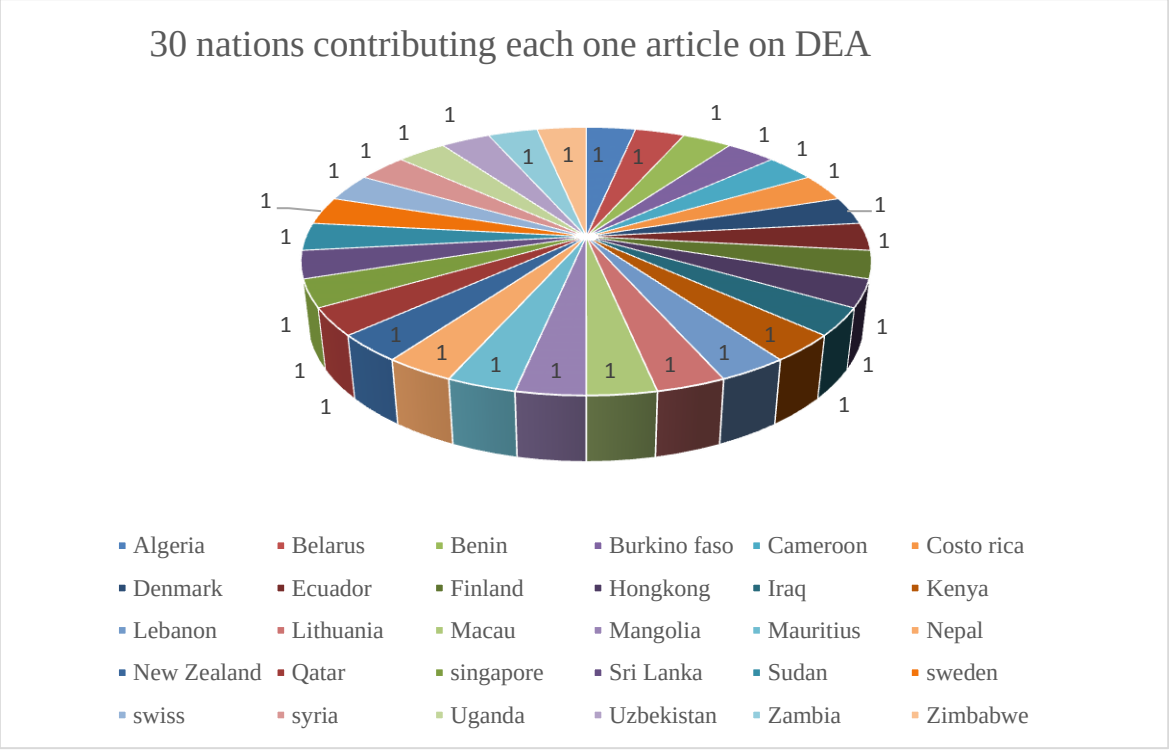


Table 1. Contribution of articles on DEA published by 89 nations

country	Number of articles	country	Number of articles	country	Number of articles	country	Number of articles
Algeria	1	Finland	1	Mexico	4	Sri Lanka	1
Australia	2	France	4	Morocco	3	Sudan	1
Austria	2	Germany	10	Nepal	1	sweden	1
Bangladesh	6	Ghana	7	New Zealand	1	swiss	1

Belarus	1	Greece	16	Nigeria	4	syria	1
Belgium	2	Hongkong	1	Oman	5	Taiwan	39
Benin	1	Hungary	3	Pakistan	17	Tanzania	2
Brazil	34	India	162	Peru	5	Thailand	5
Bulgaria	2	Indonesia	28	Poland	14	The netherlands	8
Burkino faso	1	Iran	130	Portugal	17	Tunisia	4
Cameroon	1	Iraq	1	Qatar	1	Turkey	44
Canada	6	Italy	19	Romania	3	UAE	3
Chile	5	Japan	12	Russia	6	Uganda	1
China	241	Jordon	3	South Africa	3	UK	10
Colombia	4	Kenya	1	saudi Arabia	6	Ukraine	4
Costo rica	1	Kazakhsthan	2	Serbia	8	US	42
Croatia	6	Lebanon	1	Singa pore	1	Uzbekistan	1
Cross countries	13	Lithuania	1	Slovak	10	Vietnam	17
Czech	10	Macau	1	Slovenia	4	Zambia	1
Denmark	1	Macedonia	2	South Africa	5	Zimbabwe	1
Ecuador	1	Malaysia	27	South Asia	2		
Egypt	7	Mangolia	1	South Korea	15		
Etiopia	9	Mauritius	1	spain	53		

Figure 3. Publications of 2 to 9 articles on DEA by 36 NATIONS

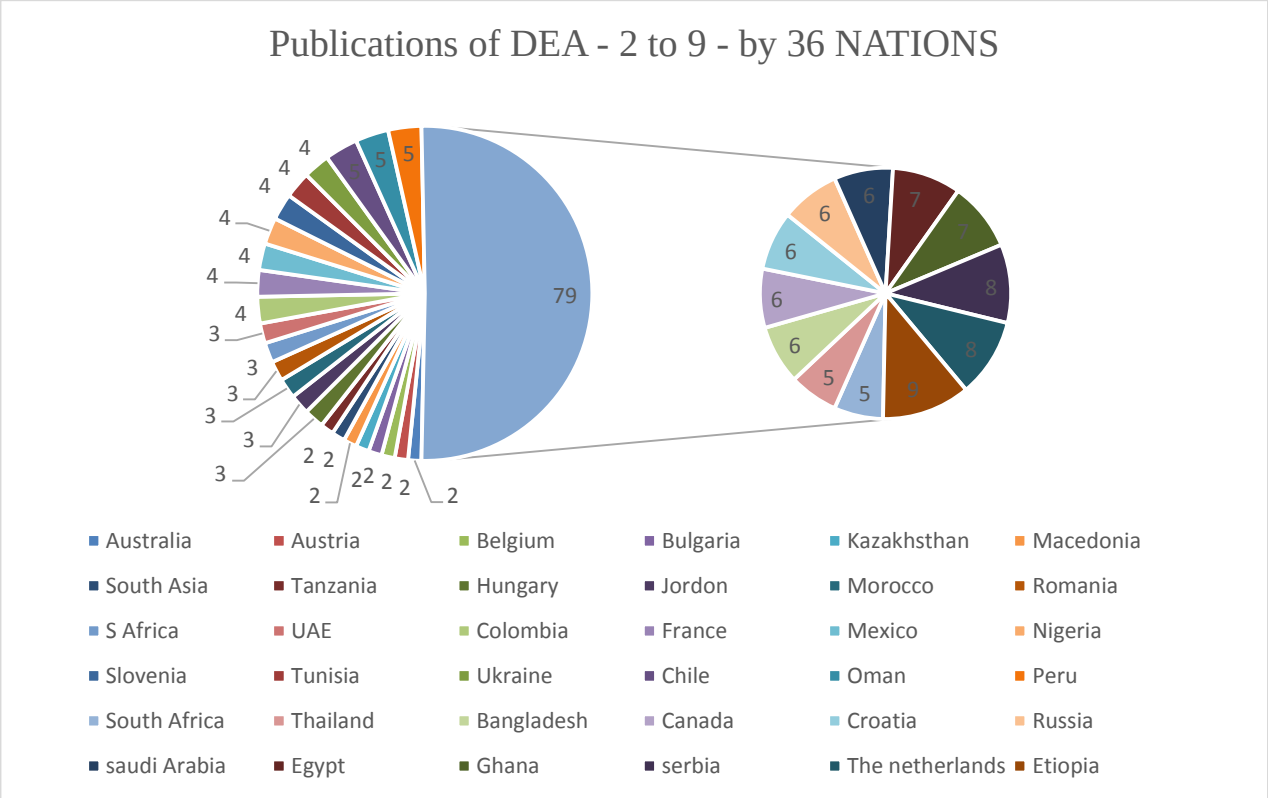
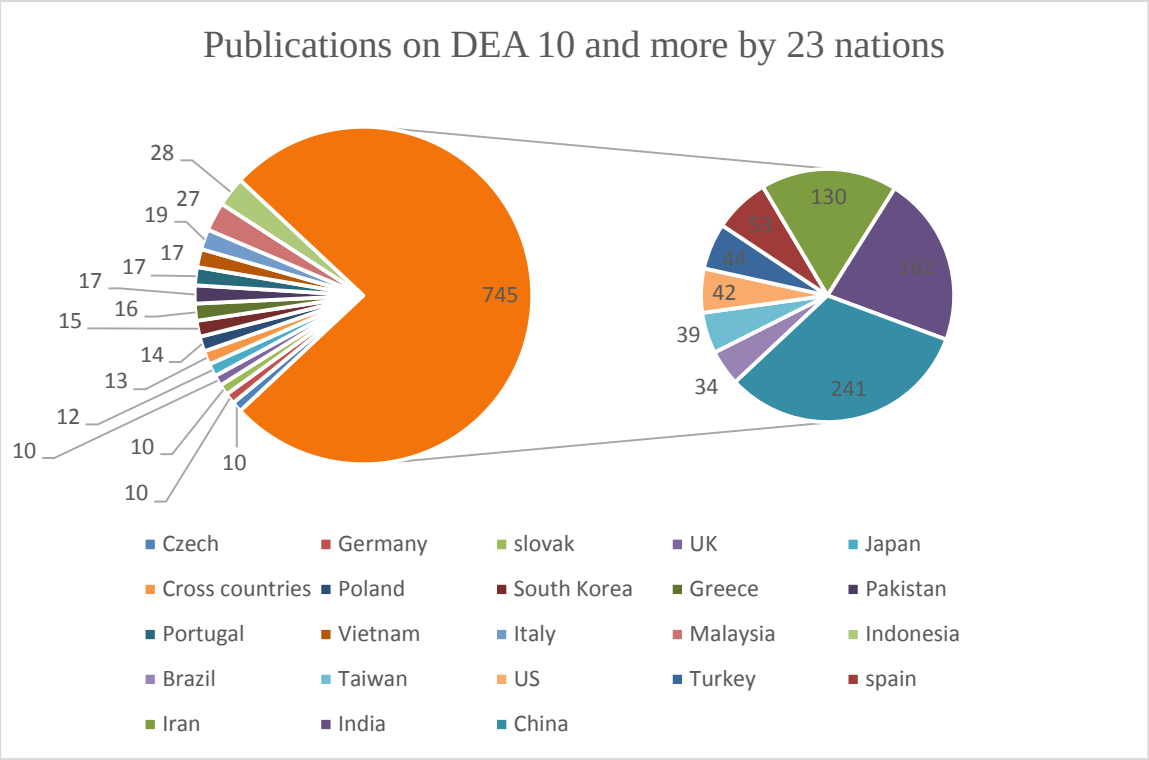
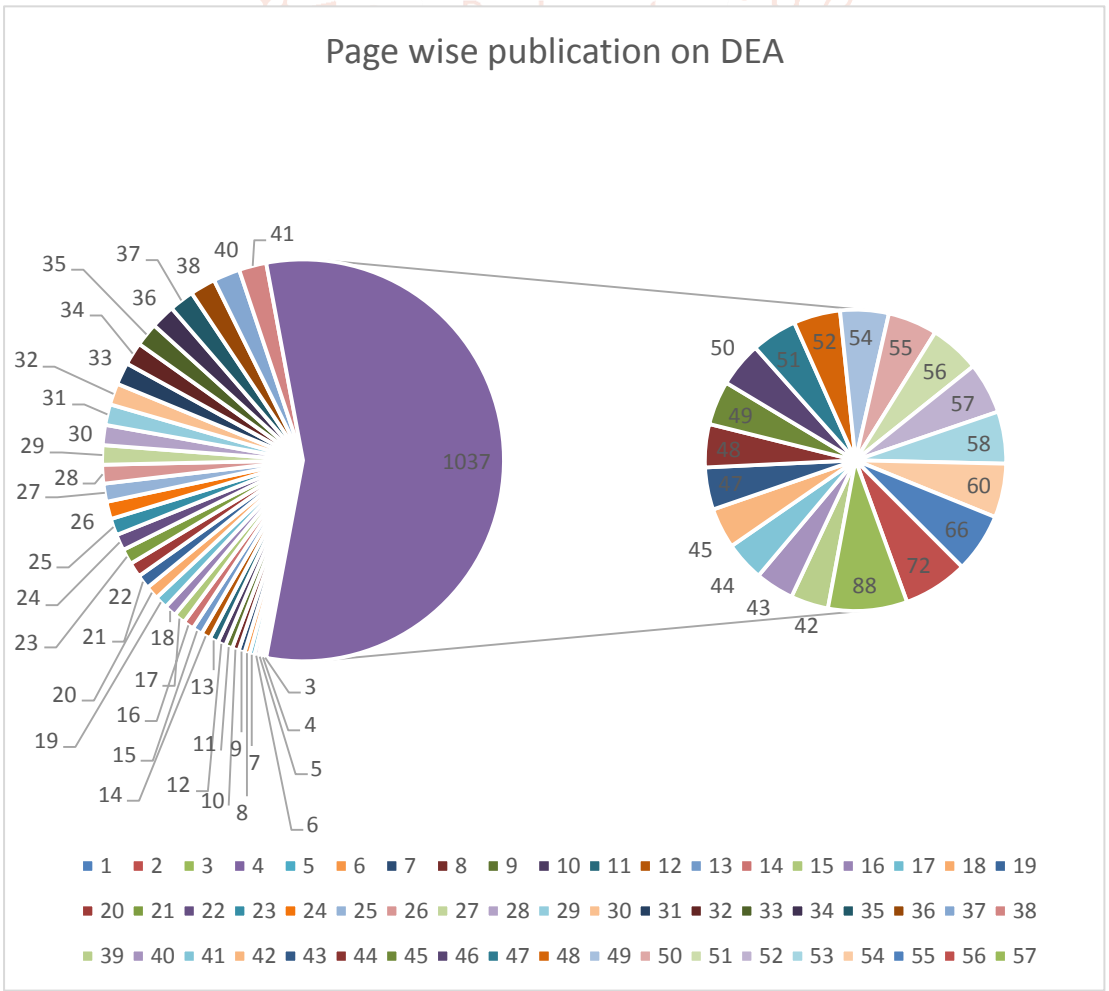


Figure 4. Publications on DEA 10 and more by 23 nations



The number of pages contained by articles ranged from the minimum of three pages to the maximum of 88 pages. The 88 page article is a review article from Chile by Leonardo Vásquez-Ibarra, LidiaAngulo-Meza, Marcela C.González-Araya, AlfredoIriarte while the three page article is from France by Matthieu Belarouci. There are three dissertations also analysed and their pages are more than hundred (viz., 170,255 and 361).

Figure 5 Publications on the basis of number of pages of articles

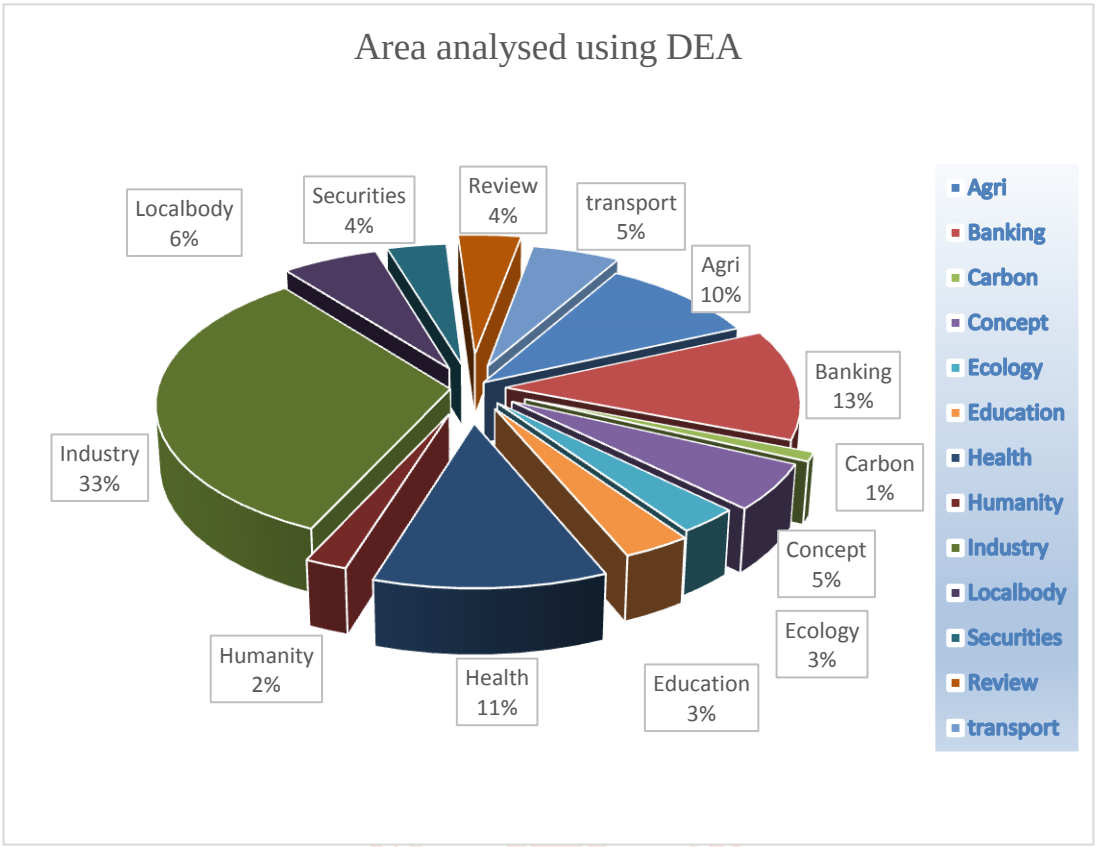


The areas analysed are agriculture, banking, carbon emission, ecology, environment, education, health, humanity, Industry (including engineering), local bodies like municipalities – area from cities to nations), securities like insurance, stock, etc., transport and reviews.

Table 2. Number of articles in 13 areas of analysis

Agriculture	117	ecology	35	local body	70
Banking	149	education	39	securities	43
carbon	12	health	133	review	46
concept	63	humanity	24	transport	64
		industry	382		

Figure 6. Publications based on area of analysis

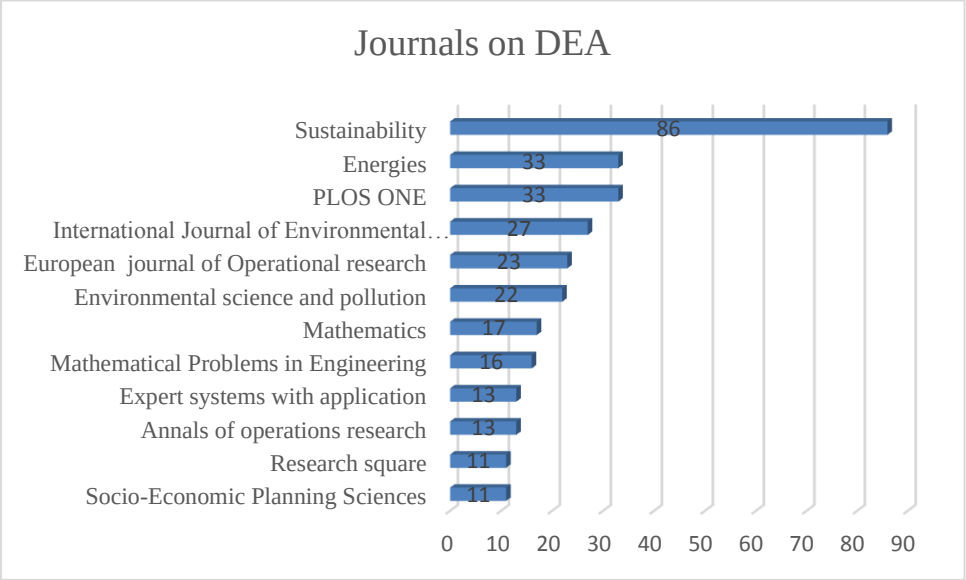


In the case of journals, as many as 426 articles are published each one by 426 journals and maximum of 86 are published by single journal viz., sustainability. There are ten journals each published more than ten articles and they are as below.

Table 3. Number of articles by 12 journals with more than 10 articles

No. of articles	Name of the Journals
11	Socio-economic planning sciences
11	Research square
13	Annals of operations research
13	Expert systems with applications
16	Mathematical problems in Engineering
17	Mathematics
22	Environmental science and pollution
23	European journal of Operational research
27	International Journal of Environmental Research and Public Health
33	Energies
33	PLOS ONE
86	Sustainability

Figure 7. Publications on the basis of journals

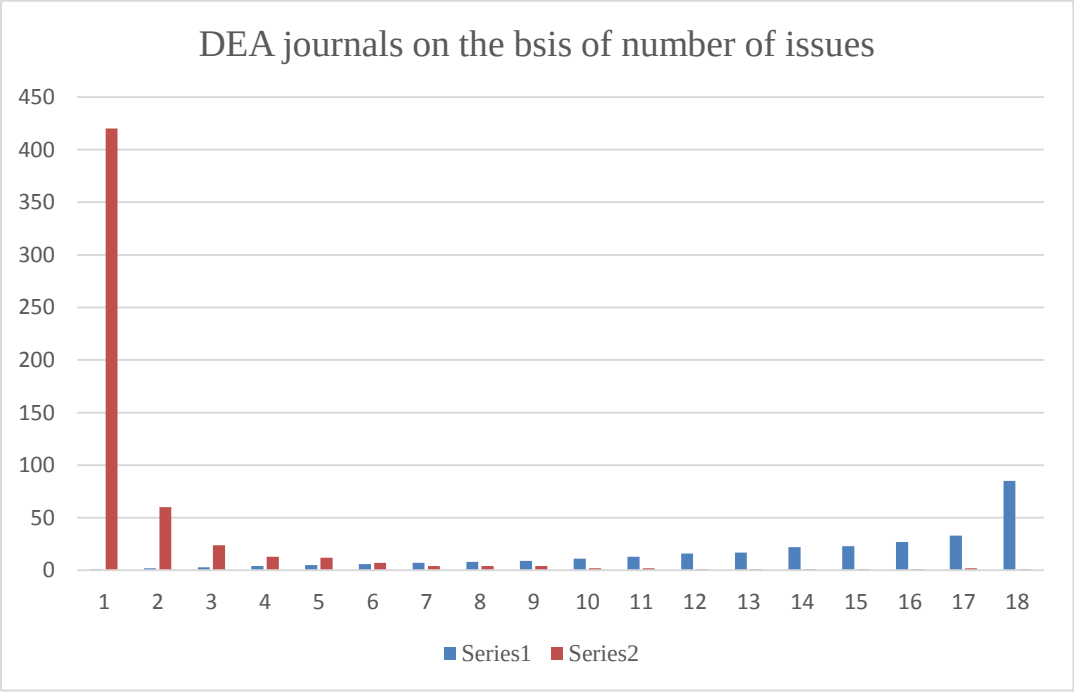


The following of table enlists the number of issues of1166 journals. It includes three dissertations each with more than 100 pages.

Table 4. Number of articles based on the publishing journals

Journals	No of articles	Journals	No of articles	Journals	No of articles	Journals	No of articles
420	1	7	6	1	12	1	23
60	2	4	7	1	13	1	27
24	3	4	8	1	16	2	33
13	4	4	9	1	17	1	86
12	5	2	11	1	22	3	>100

Figure 8. DEA journals on the basis of number of issues



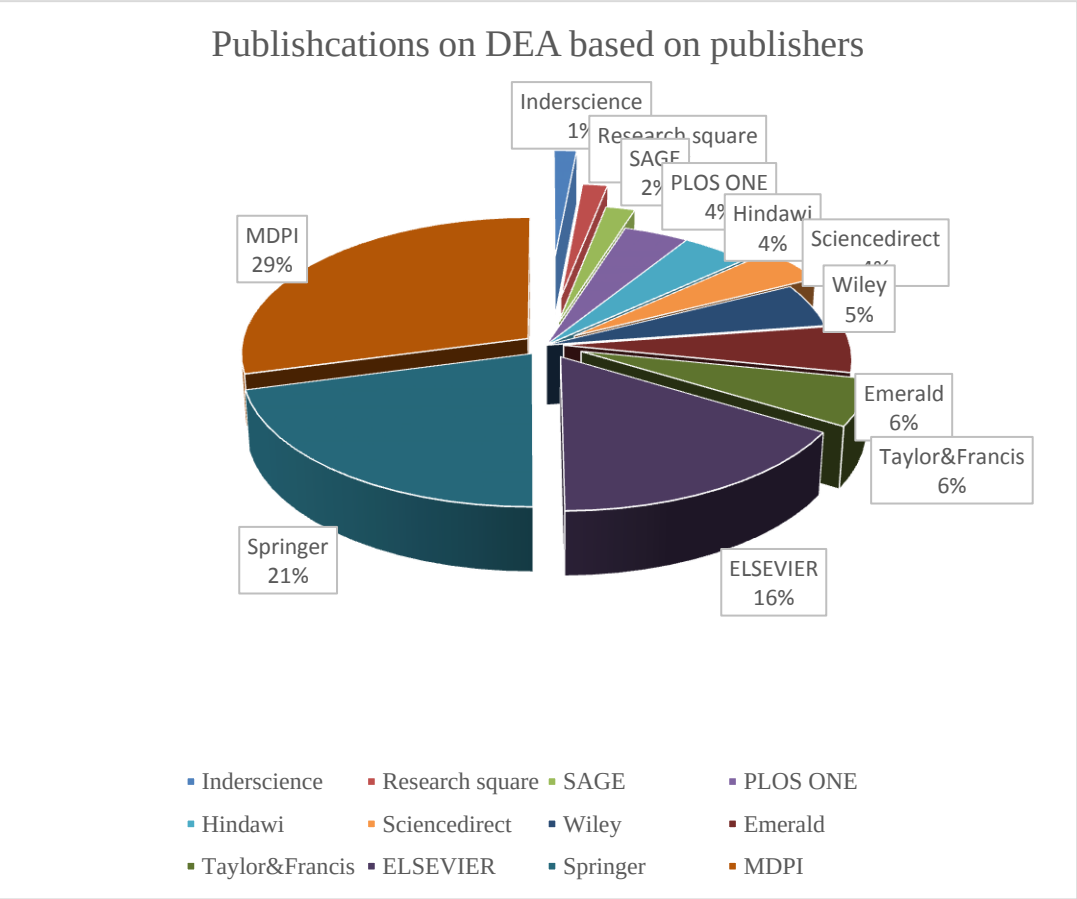
Among the publishers and data bases, MDPI stood top with 238 articles.

Table 5. Details of publishers with publications of more than ten articles

Name of the Publishers/Database	Number of articles
Inderscience	12
Research square	13
SAGE	15
PLOS ONE	33
Hindawi	35
sciencedirect	35
Wiley online library	42
Emerald	45
Taylor&Francis	45
ELSEVIER	132
springer nature	171
MDPI	238

162 articles are published by 49 publishers while 188 publishers published one article each on DEA during this review period.

Figure 9. Publications with reference to publishers and website database



Out of 1166 articles, 564 are published in the year 2020 and the balance of 602 are in 2021 (till August 2021). In these, various methods are adopted by the researchers. The approach with single analytical method by choosing either Data envelopment analysis or Stochastic frontier analysis or Analytical Hierarchy Process is found in 484 researches. In other cases of 682, new approaches and/or combination of methods have been attempted to evaluate the efficiency. The data used in some researches are inverse type, uncertain type, fuzzy type. In 406 researches, the methods are repeated and hence the details of 152 researches of 2020 and 124 of 2021 are considered for furnishing the methods followed in analysis.

For the year 2020, the number of researches published with 160 different methods are furnished below.

Table 6: Models in 2020

Aggregate directional distance function (DDF	Machine Learning + Decision Tree + Random Forest + Neural Networks
Analytical hierarchical process (AHP) combined with Best Worst Method (BWM)	Maximum likelihood estimate of the Cobb-Douglas cost function
Analytical hierarchical process (AHP), single-stage input-oriented CCR DEA, VIKOR and MPI	Fuzzy data DEA
Graph theory and matrix approach (GTMA)	Game cross-efficiency model, Theil index; Gini index,
SF TOPSIS–DEMATEL	GARCH-MIDAS Model
Fuzzy Comprehensive Evaluation method	Generalized method of moments (GMM) and Dynamic threshold model
ANOVA with SFA	Generalized true random effects stochastic frontier analysis
ARAS model of DEA	Goal programming model
ARDL Autoregressive distributed lag and Vector error correction (VECM)	Grey-holistic technique
ARDL DEA PMG	Grey-MOORA-FMF
Augmented Gravity Model	Halo + Hot deck -DEA method
Baseline analysis and Robustness tests	Hierarchy stochastic multi-objective acceptability analysis (HSMAA)
RDM model	IF BCC (IFBCC) and an IF super efficiency BCC (IFSEBCC) model
Bi-level programming (BLP) - a nested optimization problem	IF TIN
BLISA model and Geographically and Temporally Weighted Regression (GTWR) model	Impotred method MAN DEA
BSC DEA and grey relational analysis	Interval DEA and Interval Entrophy
LMDI method (Log-Mean Divisia Index), STIRPAT Model (Stochastic Impacts by Regression on Population, Affluence and Technology)	Interval-modified slack-based measure (IMSBM) model
Computable General Equilibrium MODEL	Intuitionistic Fuzzy Network Data Envelopment Analysis Models
Cloud Model	Logical Linguistic Models
Cluster Analysis	Machine Learning + Decision Tree + Random Forest + Neural Networks
Meta-frontier methodological proposal	Maximum likelihood estimate of the Cobb-Douglas cost function
Ward's method for spatial diversity	MCGDM approach combining intuitionistic fuzzy sets (IFSs) and the Characteristic Object Method (COMET)
Cobb-Douglas stochastic frontier production function	MDM- maximum deviation method and IEM improved information entropy method
p-robust technique	Meta-cost frontier
fuzzy credibility constrained programming	Least Squares and Maximum Likelihood Estimation of Stochastic Frontier Analysis
Common set of weights	Mixed-integer linear programming (MILP)
Composite indicator approach	Triangular single-valued neutrosophic numbers
Multi-criteria decision analysis	Principal component analysis (PCA)
Confirmatory Factor Analysis (CFA) + Structural Equation Model (SEM)	MSCFLP-DEA and SSCFLPDEA Models
COPRAS (Complex Proportional Assessment) method and SWARA (Step-wise Weight Assessment Ratio Analysis) approach	Sensitivity analysis, Multiple Data Envelopment Analysis (M-DEA)

CRITIC-TOPSIS and CRITIC-GRA	Nerlovian profit inefficiency (NPIE)
Regression Tree (RT)	Geographically Weighted Regression (GWR) Model
Panzar-Rosse and H-statistics model	Network Slack-Based DEA model
Parallel algorithms	Neutrosophic DEA model with undesirable outputs (SVNBCC-UO)
Conditional Mixed-process (CMP)	Non-convex meta-frontier model
Fuzzy Analytical Network Process (FANP)	Optimal Pollution Control Model
Inverted data envelopment analysis (inverted-DEA)	Order m approach
Optimal Control Theory (OCT)	Systematic Gaussian Mixed Model (GMM)
Range adjusted measure (RAM)	Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA)
Second stage regression	Associated Multi-objective Optimization Problem
Window DEA	Random Parameter Binary Probit (RPBP) model
Directional Distance Function approach	Reduced superefficient SBM models
Concept of Rough Sets	Regression Tree Analysis
Tobit regression analysis	Revised dynamic DEA model
Double Bootstrap Approach in a Principal Component Regression	Robust data envelopment analysis (RDEA) method
Multivariate analysis	Robust mean-semi variance- liquidity (RMSVL) + robust mean-absolute deviation-liquidity (RMADL) models
Non-radial enhanced Russell measure	Sample selection stochastic production frontier model
Ordered weighted averaging (OWA)	SBM undesirable DEA
Weighted Russell directional distance model	Semi-Oriented Radial Measure (SORM) DEA model
Decision tree (DT) analysis	Entropy Evaluation Method
Evaluation based on distance from average solution (EDAS) method	Simar and Wilson’s two-stage approach
Decision making trail and evaluation laboratory (DEMATEL) method	Simple Envelopment Model (SEM) of DEA
Dickey–Fuller generalised least square (DF-GLS) test, E-G co-integration test, Granger Causality Test + Spatial Autocorrelation Test + DEA Coordination Model for the Varied-Freight Model	Slack-based measure of Dynamic network Data Envelopment Analysis model (DNSBM)
Discriminant Analysis DEA	Smoothed heterogeneous bootstrapping procedures
Dynamic data envelopment analysis (DDEA) and inverse DDEA (IDDEA)	Spherical fuzzy extension of DEMATEL (SF-DEMATEL)
Dynamic Network Data Envelopment Analysis	STIRPAT (stochastic impacts by regression on population, affluence, and technology) model
Coupling coordination degree model	Super efficiency DEA-SBM Model
Exploratory spatial data analysis	Common Set Weights model (CSW-DEA)
Envelopment network model	Super SBM DEA
Exploratory Data Analytics (EDA)	Super undesirable dynamic Slacks-Based Measures
Failure Mode and Effect Analysis (FMEA)	Taguchi–Grey analysis-based criteria decision making
Intuitionistic fuzzy hybrid weighted Euclidean distance operator, and Potentially All Pairwise Rankings of all possible Alternatives (PAPRIKA)	Elimination et Choix Traduisant la Realité (ELECTRE) and Cross-Efficiency (CE)
fuzzy additive ratio assessment (FARAS)	Triple difference model (DDD)

Financial ratios analysis and efficient frontier analysis	Markov Chain Monte Carlo (MCMC)method generated simulations
Feasible Generalized Least Squares Regression (FGLS)	Three-stage chain network SBM (slack-based measure) model
Four-stage DEA approach	Three-Stage Network Bootstrap DEA
Generalized method of moments (GMM) and Dynamic threshold model	Time-Dependent Efficiency Measures
Generalized true random effects stochastic frontier analysis	Convergence Methodology: The Phillips and Sul (2007) Approach
Goal programming model	Trapezoidal intuitionistic fuzzy number; TrIFN
Grey-holistic technique	Trapezoidal intuitionistic fuzzy transportation problem is converted to a parametric transportation problem
Grey-MOORA-FMF	Two Divisional Network DEA
Halo + Hot deck -DEA method	2 fuzzy sets (GIT2FSs) + ELECTRE III (ELimination Et Choix Traduisant la Realite´— elimination and choice translation reality)
Hierarchy stochastic multi-objective acceptability analysis (HSMAA)	Unconditional and conditional estimators of the DEA model
IF BCC (IFBCC) and an IF super efficiency BCC (IFSEBCC) model	Vector Error Correction Model (VECM) + Vector Autoregression (VAR) Model
IF TIN	VIKOR technique
Imported method MAN DEA	Weighted Aggregated Sum-Product Assessment (WASPAS)
Interval DEA and Interval Entrophy	Weighted additive data envelopment analysis (DEA)
Interval-modified slack-based measure (IMSBM) model	Weighted Russell directional distance model
Intuitionistic Fuzzy Network Data Envelopment Analysis Models	Weighted Stochastic Imprecise DEA
Logical Linguistic Models	ε-KAM method

For 2021, 117 models attempted are given below.

Table 7: Models in the year 2021

2 stage model	Geometric Distance functions,
2 system SBM DNDEA	GIS analysis, SWOT analysis, BEM method, and PROMETHEE II method
3 stage model	Model with Neutrosophic Numbers
5 S method (Sort, Set in Order, Shine, Standardize, Sustain)	Imprecise DEA-based CIs and fuzzy DEA-based Cis
Adaptive neuro-fuzzy inference system (ANFIS) DEA	InDEA model introduced by Hadi-Vencheh and Foroughi
Adjustable Fuzzy Chance-Constrained Network DEA	Interval fuzzy DEA
Hesitant fuzzy linguistic terms (HFLTS)	Interval programming and robust optimisation DEA
TOPSIS	Kernel density estimation DEA and Moran's I analysis
Fuzzy technique for order of preference by similarity to ideal solution (FTOPSIS)	Latent Class Analysis (LCA)
FAHP	longitutinal DEA
Andersen and Petersen's super-efficiency DEA	Malmquist–Luenberger index (MLI)
ANN with ML and ESL	Meta frontier DEA
Balanced Scorecard (BSC) Bargaining game thought DEA	Morkovian DEA

Best worst method DEA	MRAM DEA
Bilateral DEA	Network data envelopment analysis (NDEA)
Bipolar picture fuzzy set (BPFS) as a hybrid structure of bipolar fuzzy set (BFS) and picture fuzzy set (PFS)	Network dynamic DEA
Cobb–Douglas production function	Spatial impact research
Composite index	Neuroscience DEA
Quantile Autoregressive Distributed Lag (QARDL) methods	Non discretionary DEA
Configurational approach	Non-Archimedean epsilon DEA
Network Data Envelopment Analysis (NDEA)	Non-oriented dynamic SBM DEA
Constant Elasticity of Substitution (CES) production function approach	Novel Slack-Based Data Envelopment Analysis
Continuous distribution dynamics approach	Optimal weighted cross-evaluation efficiency (OWCE)
Boosted Tree (BT), Random Forest (RF) and Logistic Regression (LR)	P graph integrated DEA
linear transformation form of Cobb- Douglas production function	Panel data method DEA
Cross efficiency framework DEA	Panel data regression models
Structural equation modelling (SEM)	Parallel mediating effect (PME) DEA
Sequential Exclusion of Alternatives methods	Pentagonal neutrosophic (PN) approach
Artificial Neural Network Approach	Probabilistic Linguistic Term set DEA
SVAR (structural vector autoregressive) and regression methods	PROMETHEE-GAIA method
Network Equilibrium Model	Quality Function Deployment (QFD) + Fuzzy Analytical Network Process (FANP)
Parabolic Intuitionistic Fuzzy Numbers (PIFNs)	Resample Slacks-Based Measure + Merger Potential Gains model
interactive web deaR Shiny	Robust cross efficiency DEA
Models without explicit inputs	Russell DEA
Pabon Lasso model	SBM network DEA
Debreu–Farrell (DF) productivity	SBM SE DEA
MABAC-OCRA-TOPSIS-VIKOR (MOTV) methods	SBSC and IFAHP Approach, Second stage network DEA model
Super-efficiency approach	Sequential DEA
Free Disposal Hull	SNA DEA
Double bootstrap procedure of Simar and Wilson	Social network DEA
Five ML models and Six ensemble models (linear regression, LASSO, Light GBM, random forest and XGBoost)	Stochastic DEA
Simar and Wilson's guidelines	Shepard's energy distance function
MOSPP with fuzzy parameters (FMOSPP)	Stochastic output distance
EFQM-Fuzzy Network DEA	Superefficient undesirable-output slack-based measure DEA (SeUo-SBM-DEA) model
Entrophy weight cloud model	SWOT-AHP approach
Entropy weight method	Taguchi method DEA
Fixed-sum undesirable output DEA	Propensity score matching
Fully fuzzy linear fractional programming problem	Third Degree Stochastic Dominance Criteria DEA
Fuzzy VIKOR (Vlse Kriterijumska Optimizacija Kompromisno Resenje)	Tolerance model
Fuzzy Analytical Hierarchical Process	Trapezoidal fuzzy Best Worst Analytic Hierarchy - trapezoidal fuzzy BWM + Trapezoidal fuzzy Analytic Hierarchy Process

	(AHP)
fuzzy cross efficiency DEA	Trapezoidal Type-2 Fuzzy AHP Method
Fuzzy ideal DMU (FIDMU) and fuzzy anti-ideal DMU (FADMU)	Two-stage common weight DEA-Based approach
Fuzzy logic approach	Two-Stage IFDEA Model
Fuzzy non radial DEA	uncertain DEA
Fuzzy risk assessment DEA	Uncertain SBM data envelopment analysis
Fuzzy Slacks Based Measure (SBM) DEA Model	Undesirable factors and marginal rates of substitution DEA
Fuzzy Stochastic DEA	Z AHP DEA
Generalized Linear Models	Zero sum gains DEA (ZSG DEA)
Genetic programming approach	Geometric Distance functions,

Table 8: Details of software (Commercial)

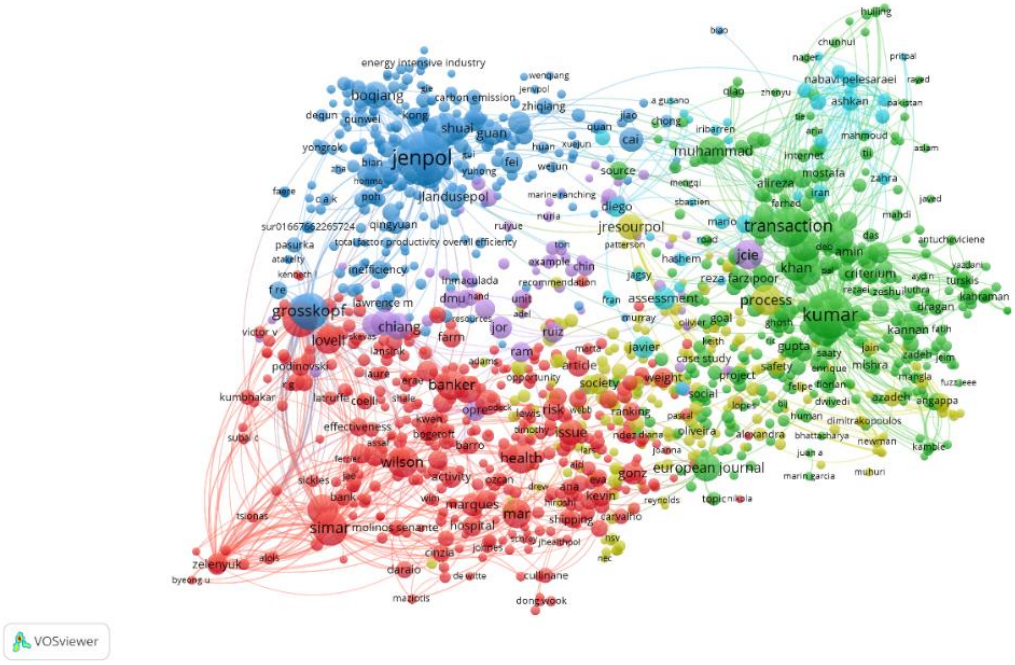
SL No	Software's name	Source
1	Data envelopment analysis On Line (DEAOS)	http:// www. deaos. com
2	PIM-DEA	http:// www. deasoftware. co. uk/ About Developers. Asp and http:// www. dea- analysis. Com
3	DEA Solver-Pro 4.0	http:// www. saitech-inc. com/ products/ prod- dsp. asp SAITECH, Inc., 1 Bethany Road, Hazlet, NJ 07330
4	MaxDEA	http:// www. maxdea. Cn
5	Frontier Analyst, version 3.1.5 and 4	www.banxia.com Banxia Software Ltd. P.O. Box 134, Kendal, LA9 4TP, UK
6	OnFront, version 2.02	www.emq.com EMQ AB, Box 2134, SE-220 02 Lund, Sweden;
7	Warwick DEA	https:// warwick.ac.uk/fac/soc/wbs/subjects/orms/research/areas/dea/ Emmanuel Thanassoulis, Aston Business School, University of Aston, Birmingham B4 7ET, UK
8	DEA software online output	https:// onlineoutput. com/ dea- software/
9	IDEAS	https:// www. softwareideas. Net
10	DEA Analysis Professional (formerly KonSi Data Envelopment Analysis DEA) 5.1	https://www.softpedia.com/get/others/finance-business/KonSi-Data-Envelopment-Analysis-DEA.shtml

Table 9: Details of software (Non commercial)

SL No	Software's name	Source
1	DEAFrontier	http:// www. deafrontier. Net Joe Zhu, Department of Management, Worcester Polytechnic Institute, 100 Institute Road, Worchester, MA 01609
2	DEAP 2.1	http:// www. owlnet.rice.edu/~econ380/ DEAP. PDF Tim Coelli, CEPA, School of Economics, University of Queensland, Brisbane Australia
3	EMS: Efficiency Measurement System, version 1.3	https:// www. holger-scheel.de/ems/ Holger Scheel, Operations Research und Wirtschaftsinformatik, Universität Dortmund, D-44221 Dortmund, Germany
4	Generalized Algebric Modeling System (GAMS) 40.1.0 / 1 August 2022	https://www. gams.com/download/
5	pyDEA	https:// pypi.org/project/pyDEA/
6	Qhull	http:// www. qhull. org/ download
7	SAS/OR	https:// www. sas.com/ en_in/home.html

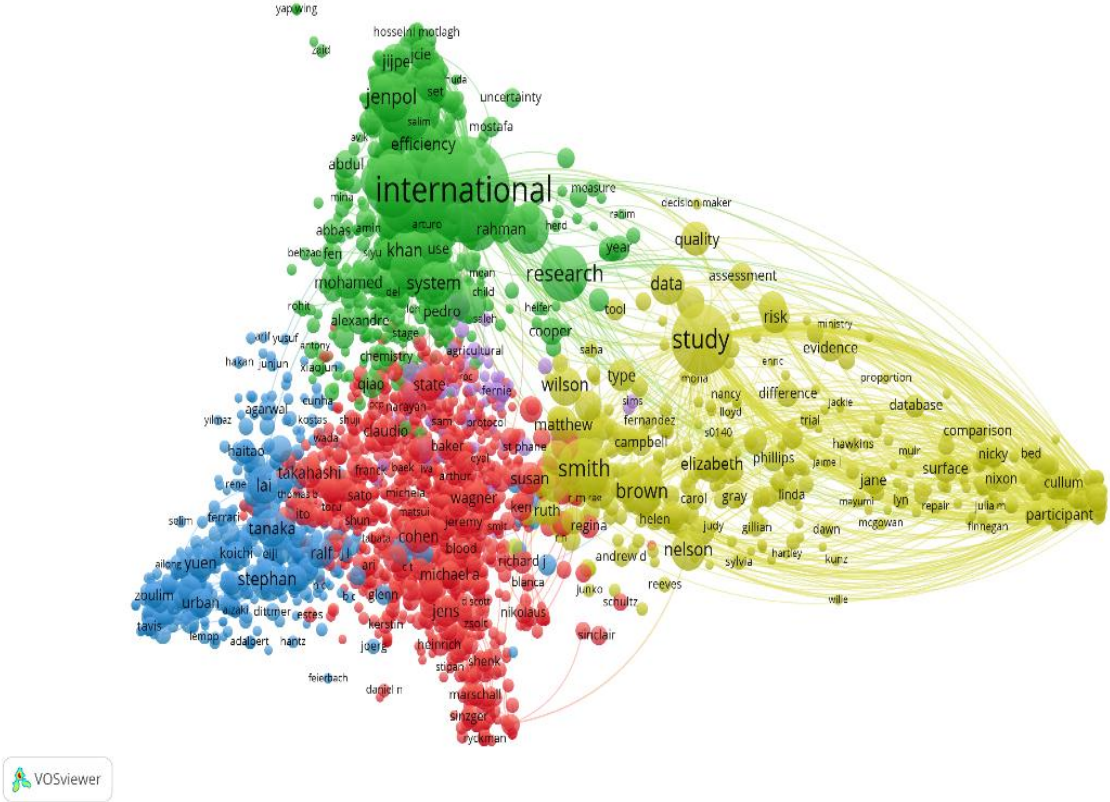
3. Visualization of similarities by mapping through VOSviewer

The bibliographic map clusters the documents, Sources, Authors, Organisations and countries. The common colours used to differentiate the clusters are red, green, blue, purple. In green, the two different types are dark green and yellowish green. In blue, two different types namely dark blue and light blue are used.



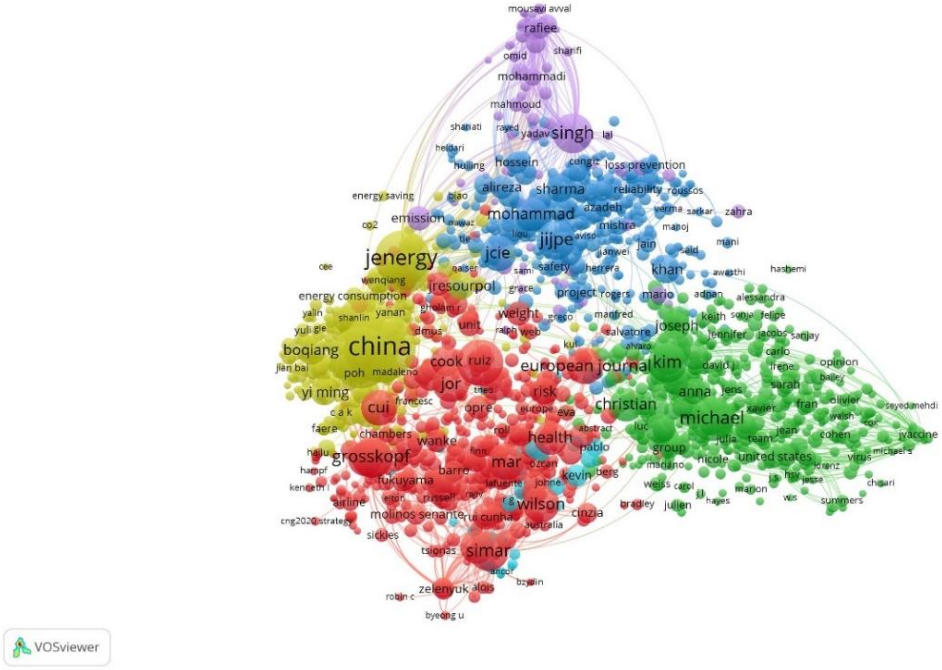
I. Bibliographic map created with CSV file containing details of DEA articles in the year 2020 and 2021.

The bibliographic map above with red colours has items Simar and Wilson in labelled circle while with green colour the items labelled are Kumar as well as Khan and in red colour, the same is Grosskopf and in purple colour it is Chiang. The document co-occurred is European journal. The topic co-occurred is health in red coloured cluster while it is energy intensity industry in blue coloured cluster. Transaction, assessment and process are common terms co-occurred in green labelled cluster. In light blue, the country Iran finds its place as a co-occurring term.



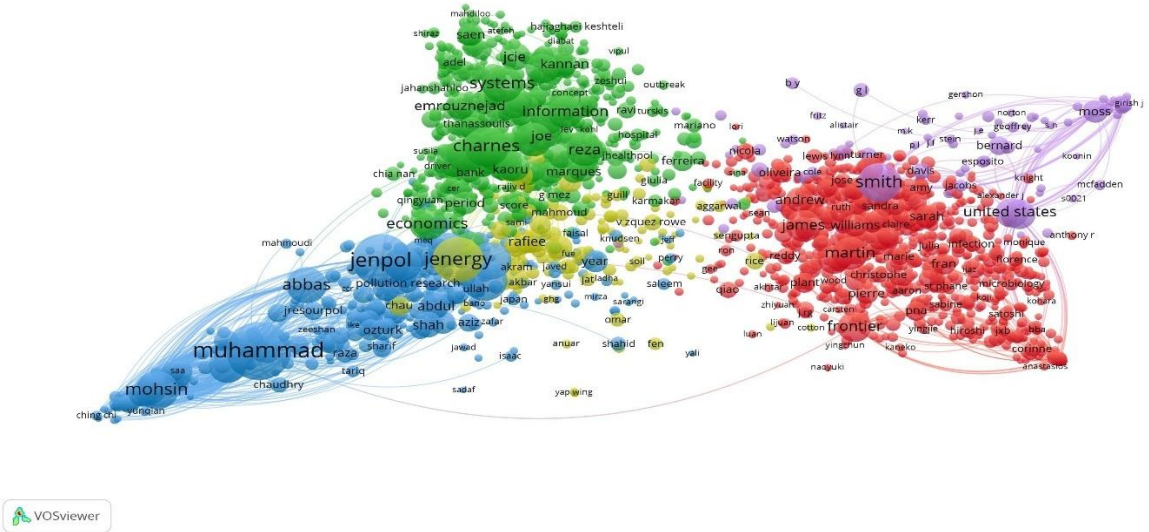
II. Bibliographic map created with CSV file containing details of DEA articles in the year 2020 and 2021.

The co-occurred items are Wilson, Nelson, Smith, Elizabeth (in yellowish green), Takahashi , Cohen, Susan,Wagner (in red colour), Tanaka, Agarwal, Yuen, Stephan (in blue colour), Mohamed, Jenpal, Khan, Mostafa (in Green clour). The co-occurred items are international, system, research, chemistry (in green color), study, risk, data, database, participant, evidence in yellowish green. The red and blue coloured are more labels with author's names.



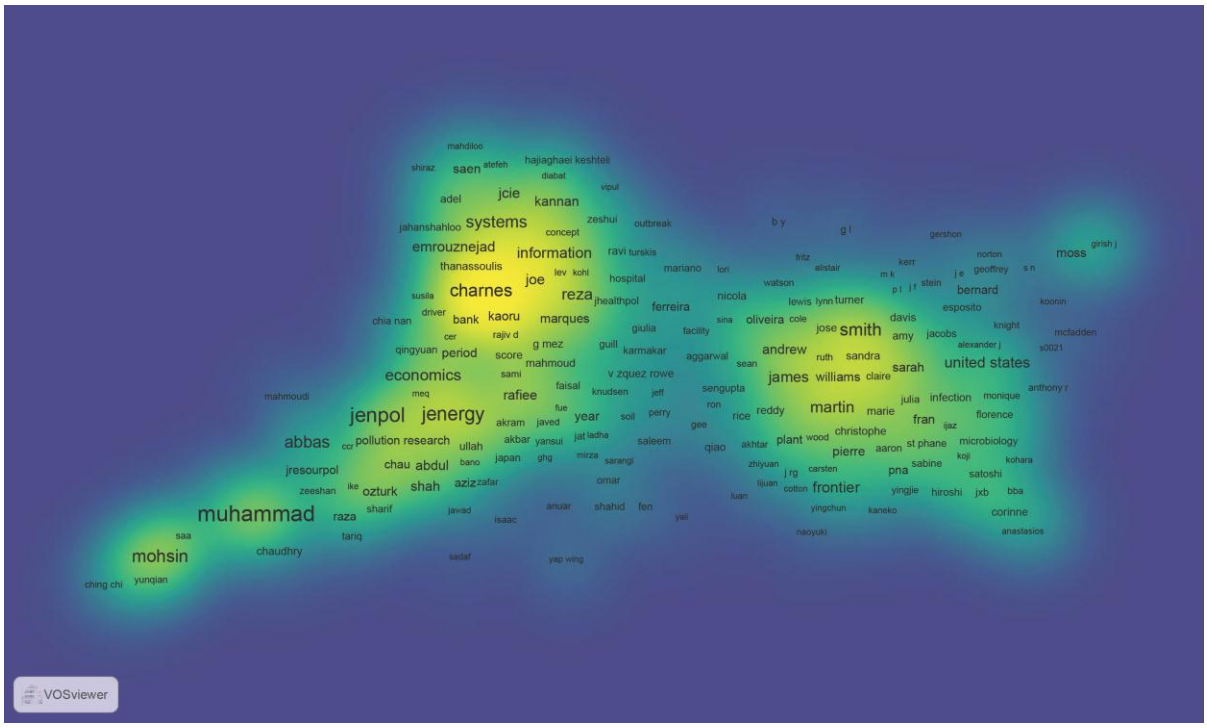
III. Bibliographic map created with CSV file containing details of 350 DEA articles in the year 2020 and 2021

The red coloured cluster is with big labels bearing items Simar, Wilson, Grosskopf, Zylenyuk, Wanke, Cui, Ruiz,health, European journal. The green cluster is with Kim, Joseph, Michael, Christian. The blue colour is with Mohamed, Khan, Sharma and loss prevention. The labels in pale green colour cluster is with china, energy and Boquaing. The purple cluster is with labels having terms Singh, Rafiee, Mohammadi.



IV. Bibliographic map created with CSV file containing details of DEA articles published in the year 2020 and 2021

The purple coloured cluster is with big labels containing items United states, Smith, Moss. The red coloured cluster is having labels bearing co-occurred items Andrew, James and Martin. In green labelled cluster, the co-occurred items are Reza, Charnes, Marques, Kaoru, Kannan. In blue coloured cluster, the co-occurred items are Muhammad, Abbas, Mohsin. In pale green, Rafiee and energy are co-occurred items.



V. Item density visualization for the bibliography IV. This figure by default has three colours namely blue, green and yellow. The item density is low in blue and increases in green and total strength is seen in yellow. Here the network visualization is not seen as this is only to show the density of items.

4. Conclusion

The earlier review made with global perspective has covered the period upto February 2020 and thereafter 46 reviews have come and all these focused on particular aspect in DEA and so the authors here attempted to cover the publications for the period of entire 2020 and eight months in 2021. This is made easy by the searches in open access databases by which 1166 articles are collected for analysis. The publications in 2021 upto August itself outnumbered the total number in entire 2020. This will be a handy journal covering the contributions of authors, nations, the methods and some details of the contents of the articles. The major contributing country is china followed by India and Iran. Among authors, journals the major contributors are Chia Nan Wang and Sustainability respectively. Among publishers, MDPI published highest number of 238 equalling to 29 %. The methods adopted in researches are so many that it cannot be precisely grouped albeit the basic methods are DEA, MPI, SFA, AHP are common along with other methods which the researchers choose to fit for the best result. The future of the research in Data Envelopment is progressing with fuzzy data and suitable combination of MCDM with DEA.

References:

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